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Some thoughts about future requirements of climate prediction

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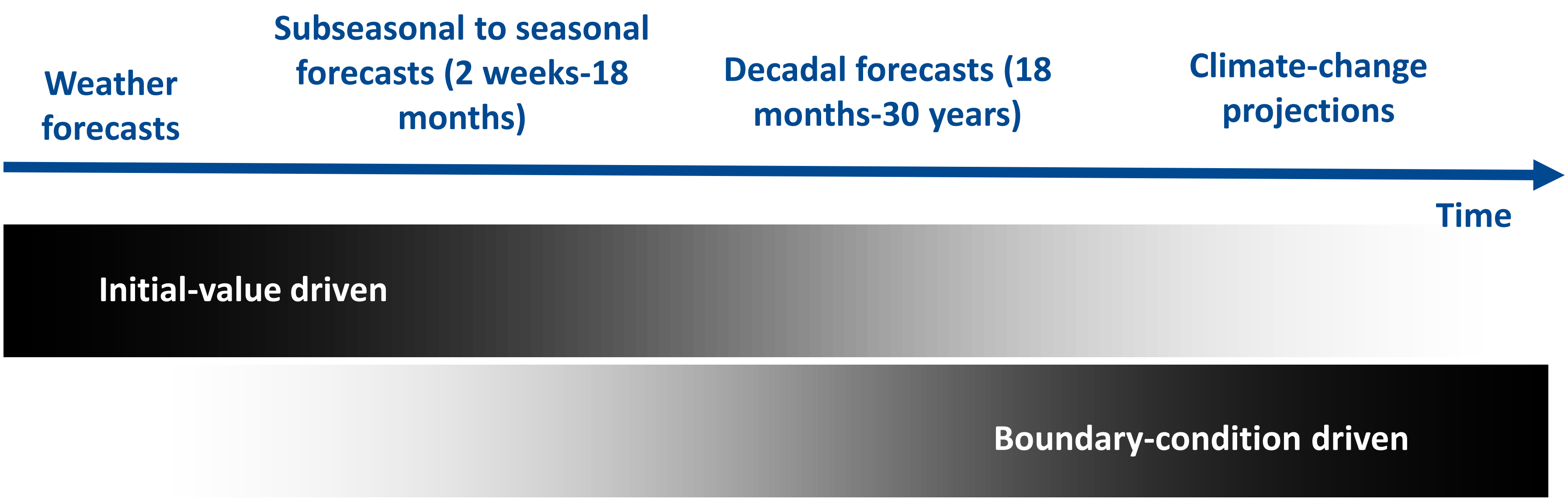
Climate prediction time scales

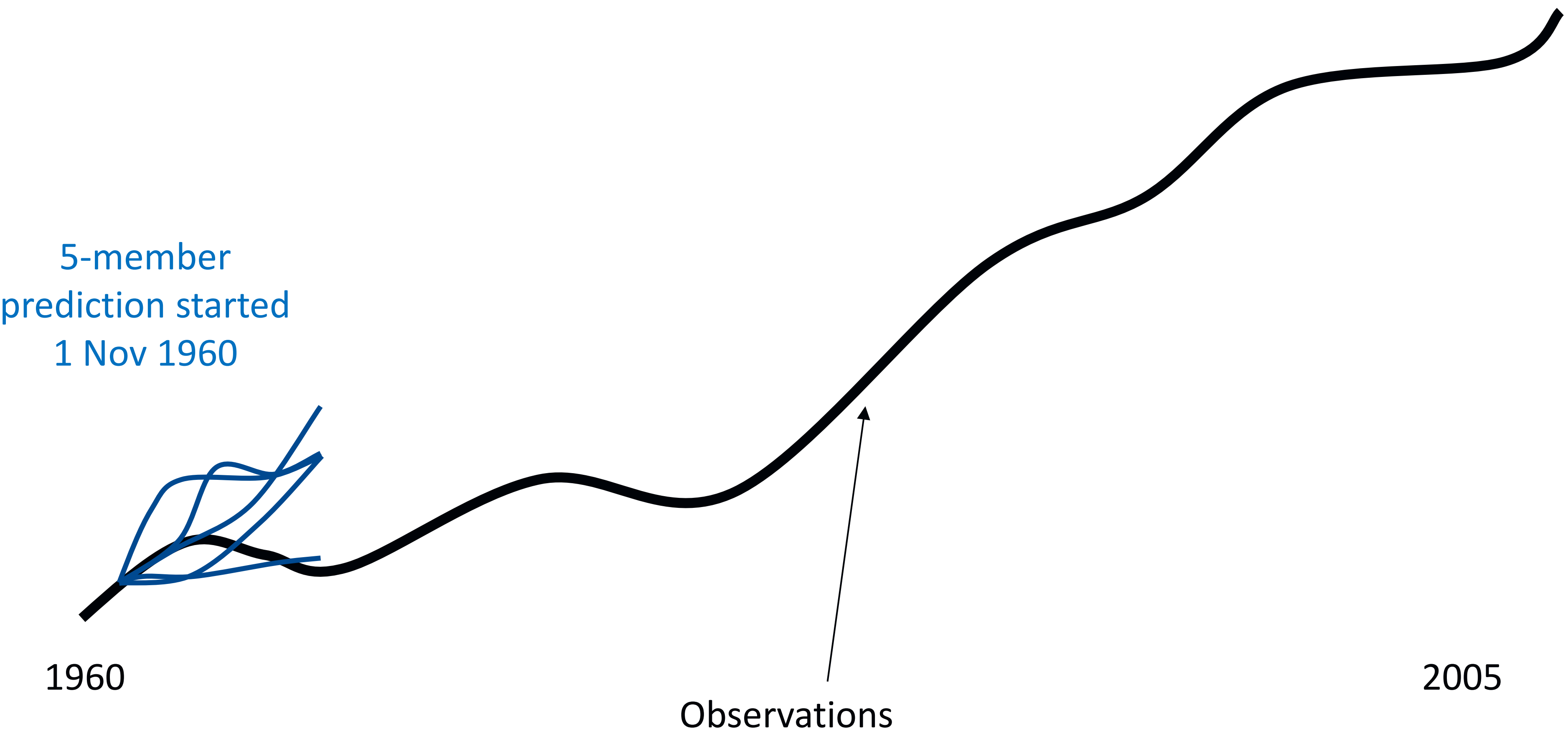
Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and validation/verification.

Climate prediction is part of WCRP (research) and C3S (operations).

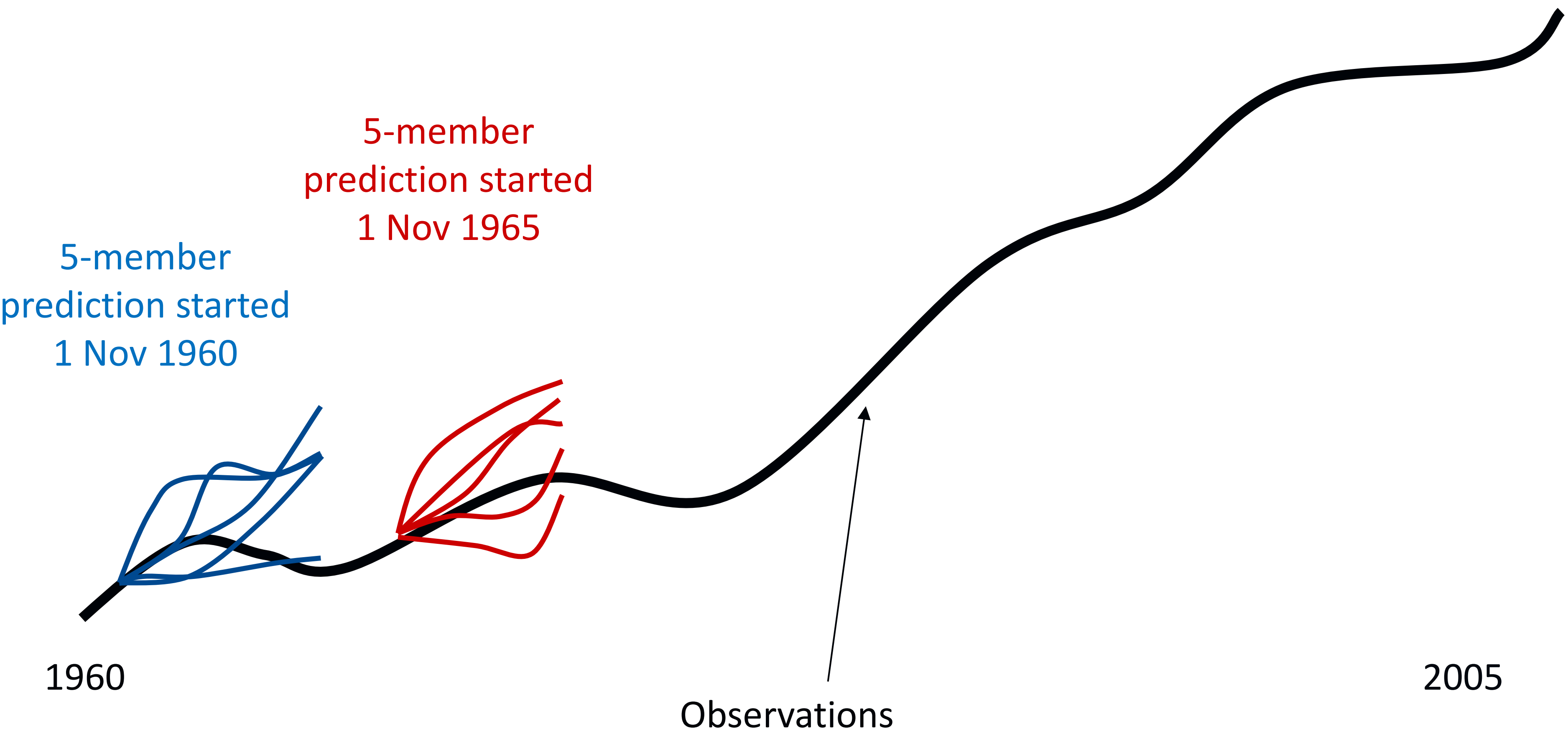


Adapted from Meehl et al. (2009)

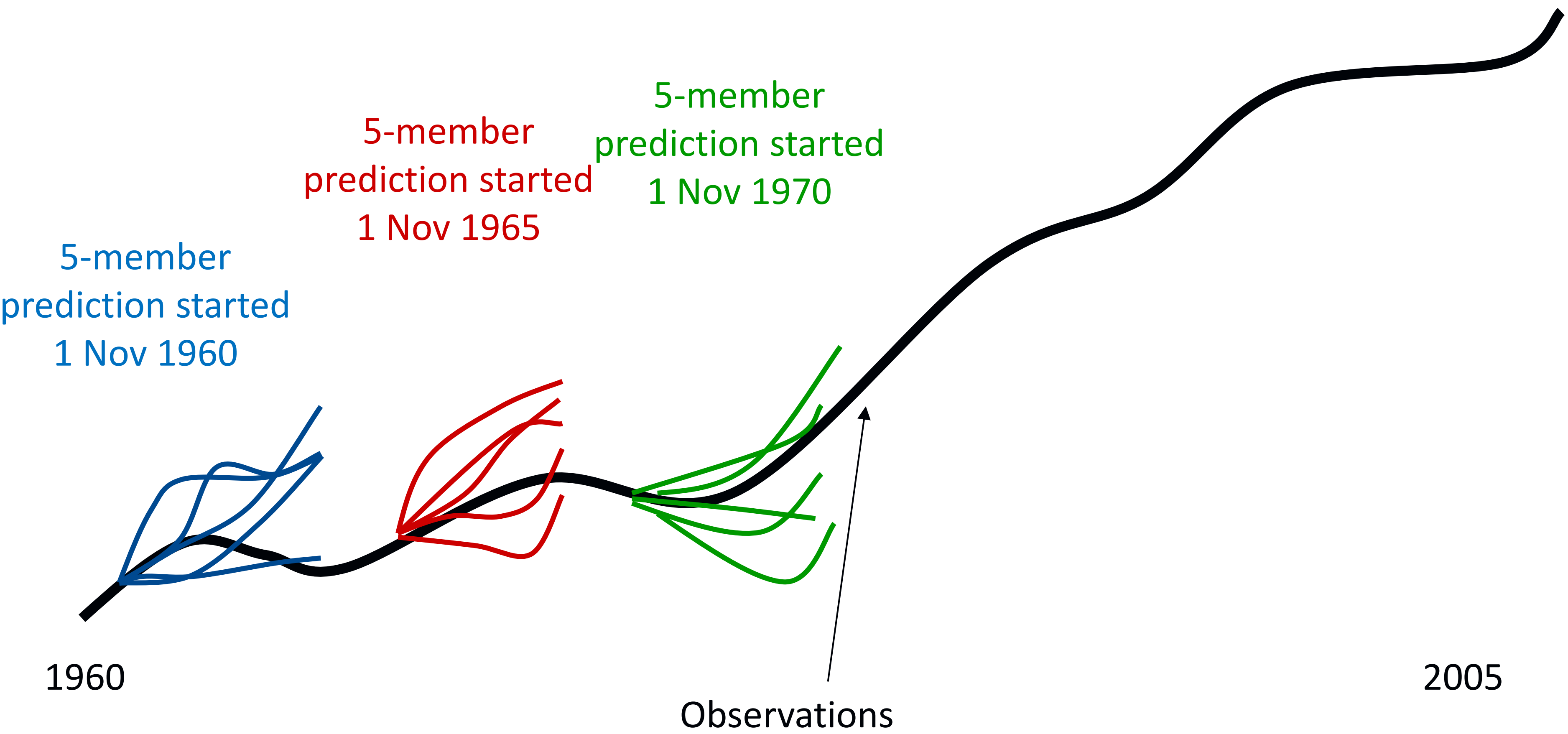
Climate predictions



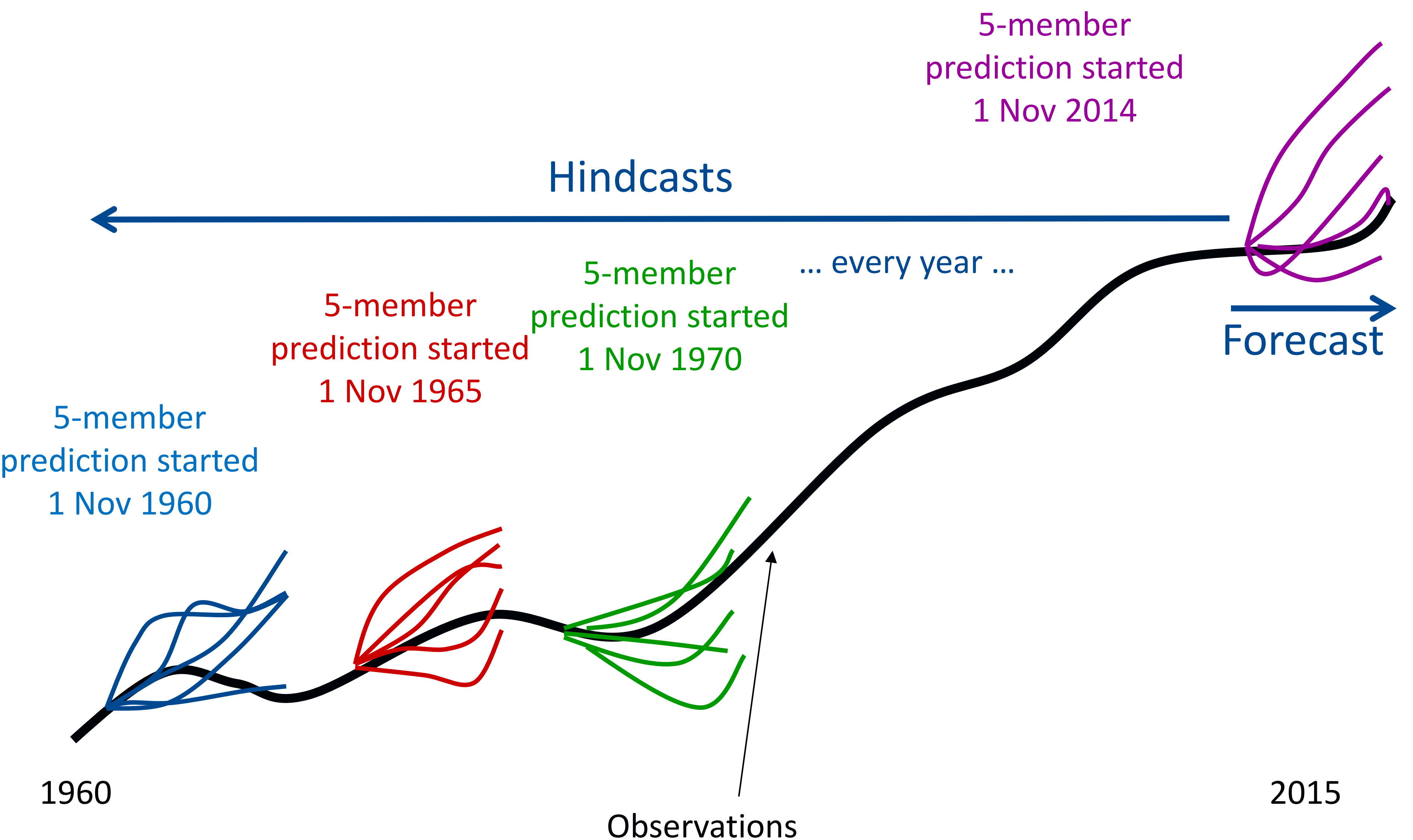
Climate predictions



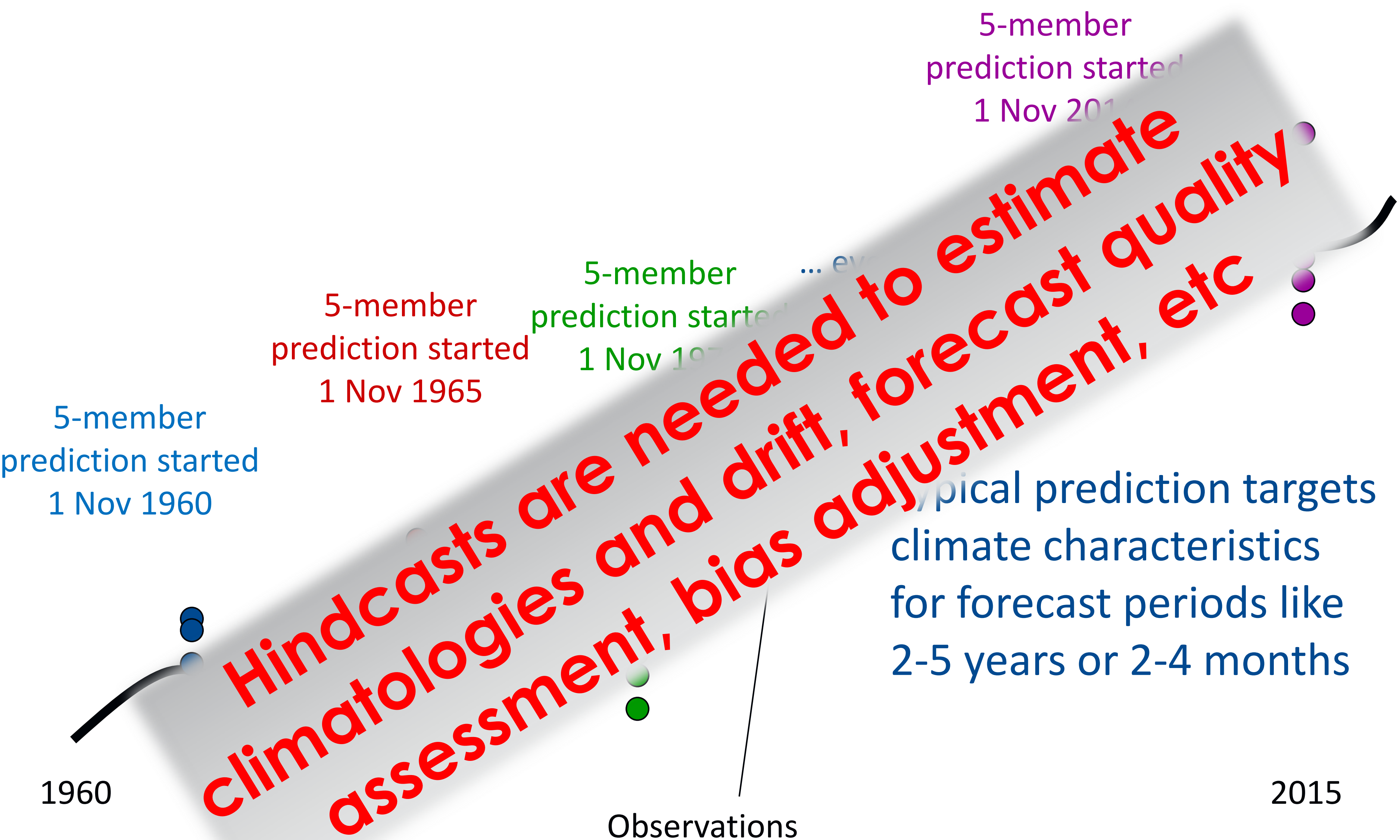
Climate predictions



Climate predictions



Climate predictions



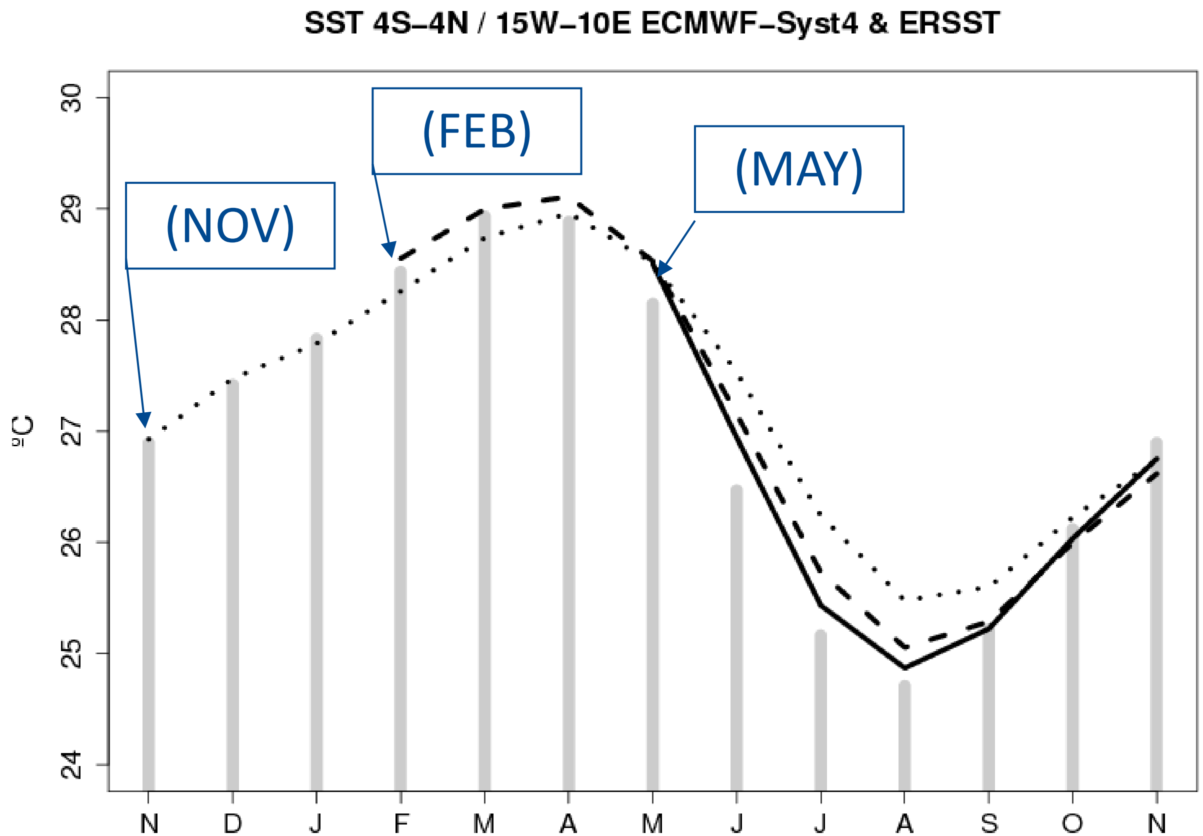
Hindcasts are needed to estimate climatologies and drift, forecast quality assessment, bias adjustment, etc

ypical prediction targets climate characteristics for forecast periods like 2-5 years or 2-4 months

Hindcasts to estimate drift

Tropical Atlantic (4ºS-4ºN, 15ºW-10ºE) averaged SST 1982-2008 for ERSST (observations, grey bars) and ECMWF System 4 with start dates May, February (three months ahead), and November (6 months).

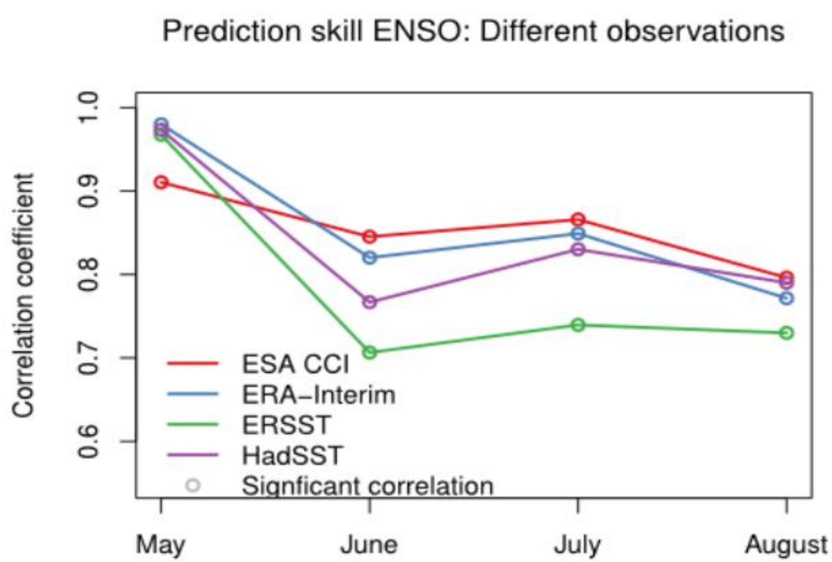
The drift is a symptom of the physical processes the model uses to shift from the initial conditions to its attractor.

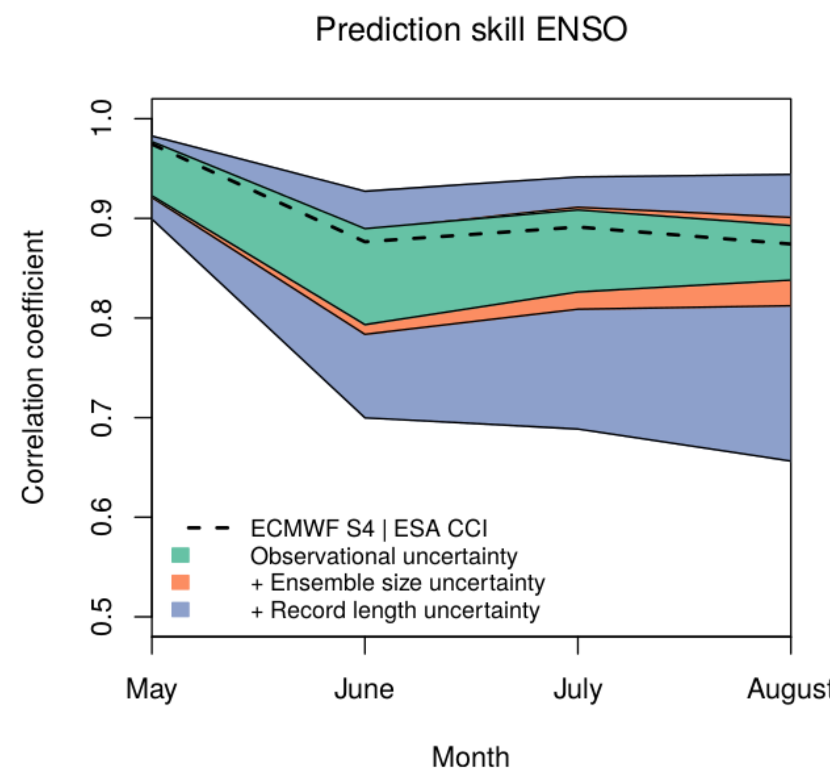


Doblas-Reyes et al. (2013, WIRES Clim. Ch.)

Hindcasts for skill assessment

Niño 3.4 SST correlation of the ensemble mean for (left) EC-Earth3 (T511/ORCA025) predictions started every May over 1993-2009 with ERAInt and GLORYS2v1 ics, and internal sea-ice reconstruction and (right) ECMWF System 4, both started every May over 1993-2010.





Bellprat et al. (2016, Rem. Sens. Env.)

Climate prediction simulations

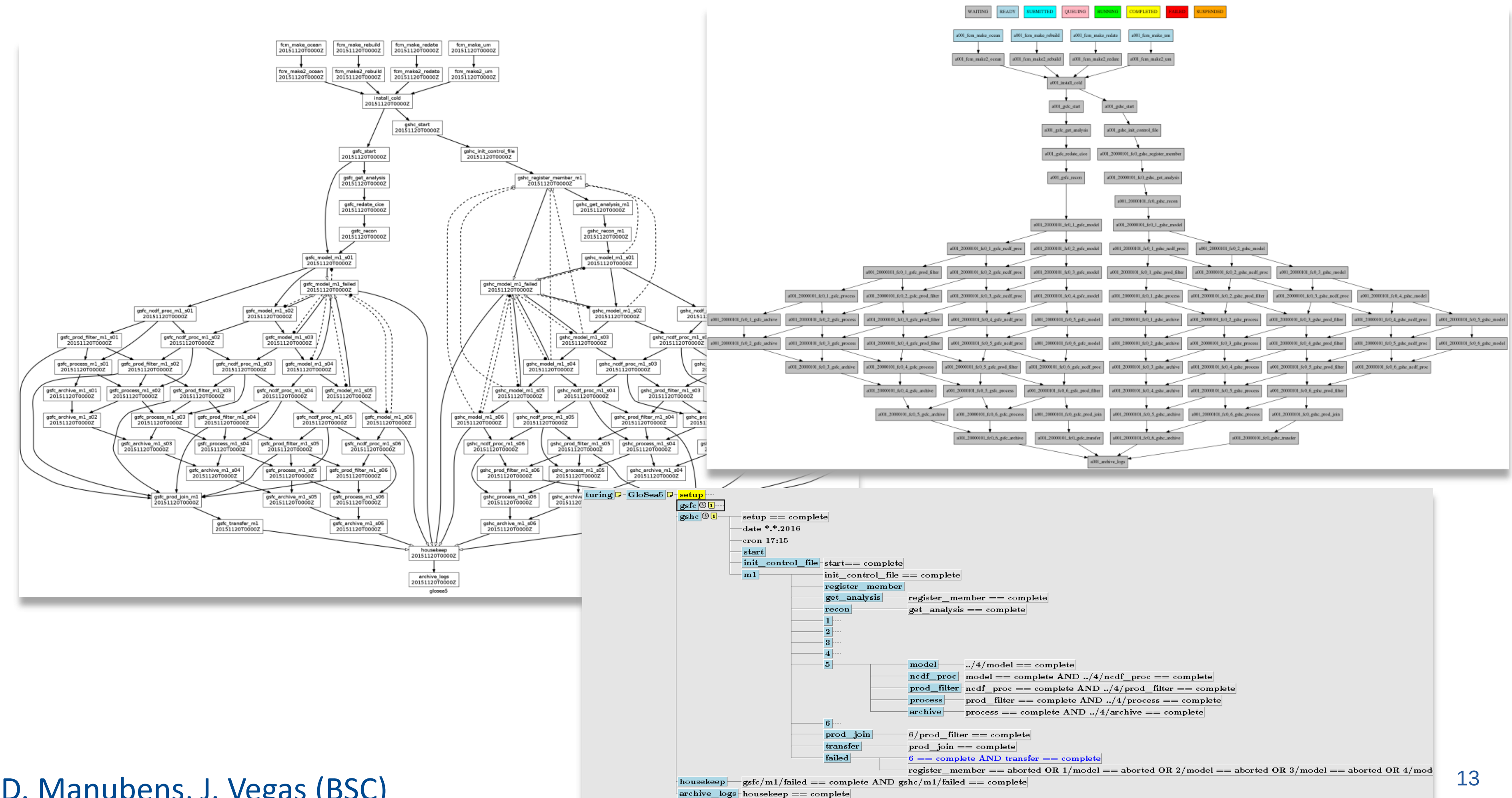
Some characteristics:

- Lots of independent jobs (10-to-100 member ensembles) that can run simultaneously -> efficient workflows.
- Piggybacking on other communities (weather forecasting, long-term climate change, CCM) to inherit all sorts of model improvements (both physical and computational like capability or data standards).
- Both operations (scheduled simulations, time to solution limited, capability) and research (no time to solution limited, best use of both HPC capacity and resources allocated).
- Need ensembles of initial conditions (sequential experiments, complex workflow, expensive in both computing and storage).
- Provenance and documentation is still very poor in climate prediction (e.g. no controlled vocabularies for data assimilation or initialisation).
- Reproducibility is an issue in opportunity platforms (e.g. DCPP).

Workflows

Complex workflow, a large number of jobs can be run simultaneously.

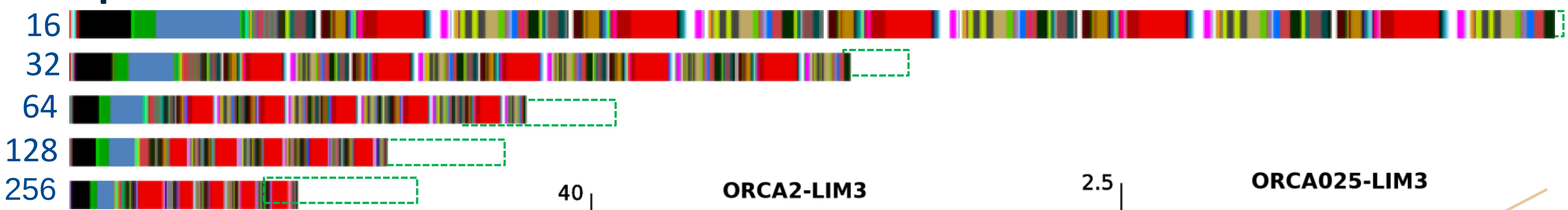
Simplified view of the GloSea5 workflow implemented in Autosubmit, Cylc and ecFlow..



NEMO optimisation for CMIP6

Original code

Optimised code



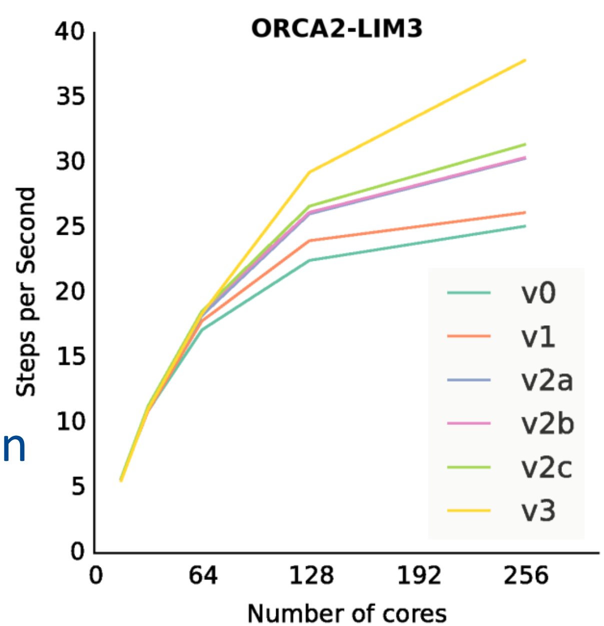
NEMO/LIM 3.6

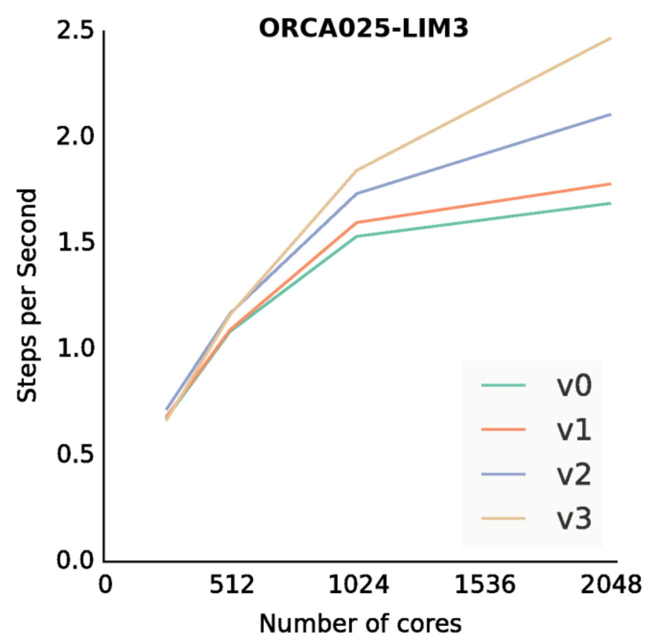
V0 → Original

V1 → Message packing

V2 → Conv. check reduction

V3 → Reordering





O. Tintó, M. Castrillo (BSC)

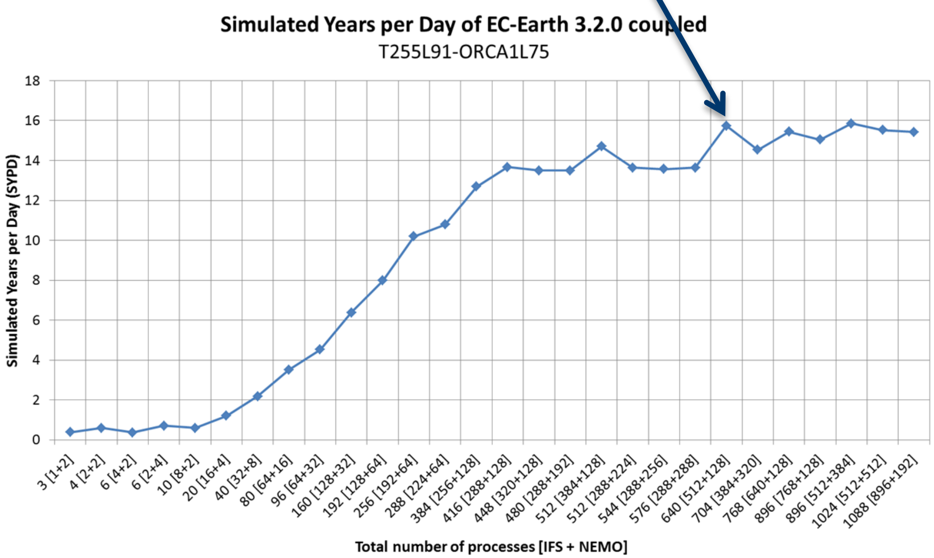
Balancing throughput and speed

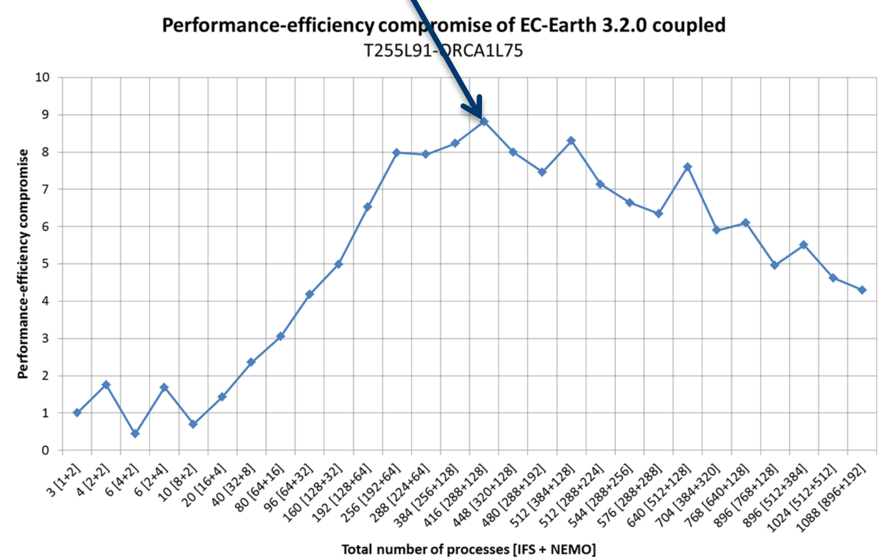
SYPD and "performance-efficiency compromise" metric (speedup * parallel efficiency) for different core number combinations with EC-Earth3.2 (standard configuration).

The combination (288 IFS,128 NEMO) uses 25% less resources and takes 13% more time to solution than (512 IFS,128 NEMO).

15.7 SYPD
7.6 compromise metric
976 cpu-hours per year

13.7 SYPD
8.8 compromise metric
732 cpu-hours per year



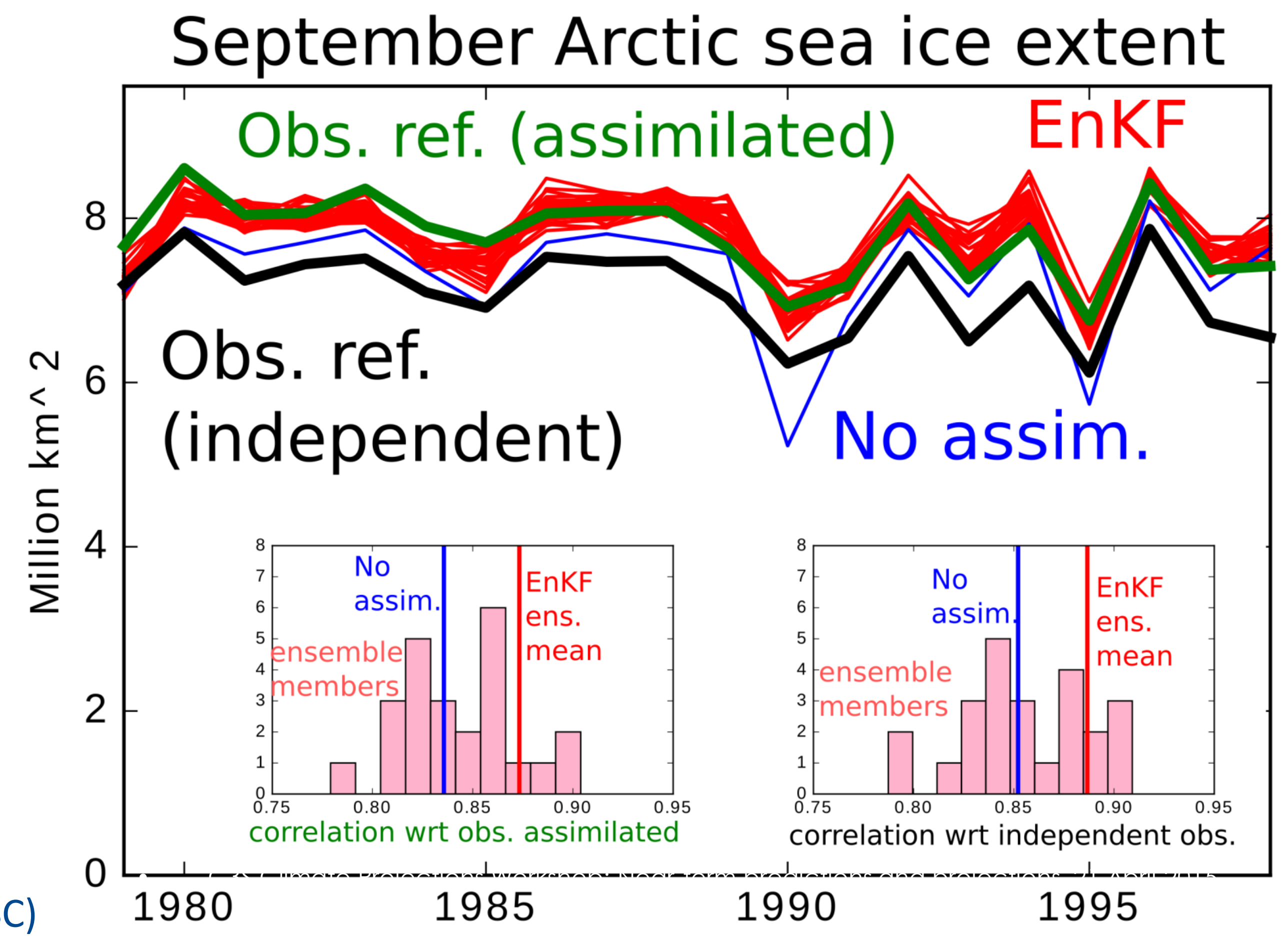


Yepes et al. (2016, BSC-ES Tech Memo)

Ensemble initial conditions needed

Ensemble Kalman filter sea-ice reanalysis with the coupled EC-Earth3.2 (24 members) assimilating ESA-CCI and OSI-SAF sea ice concentration.

About 1 million CPU hours, 55 TB of output and 4 months per day with a one-month assimilation cycle.



F. Massonnet (BSC)

We are entering untrodden terrain

To understand how to manage human impacts, the traditional approach of starting with climate models then running impact models, then looking at how to adapt, will not work.

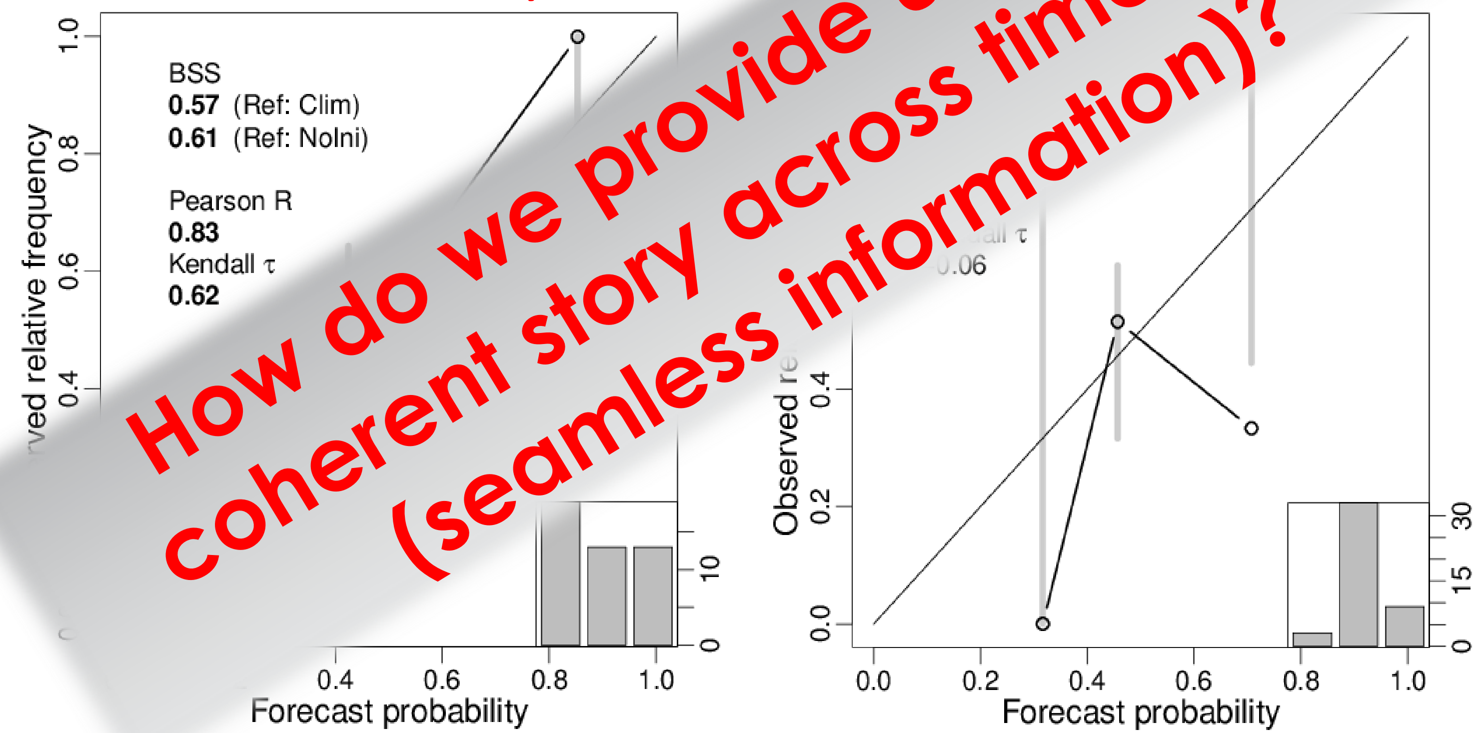
Red Cross/Red Crescent Climate Centre Director, Maarten van Aalst

Service-driven decadal predictions

Reliability diagrams of (left) initialised and (right) uninitialised MME simulations for basin-wide **accumulated cyclone energy** (…E). The results are for 2-9 year averages above the climatologi… over 1961-2009. Statistically significant values are in b…

Some of the added value of the pr… …etter management of uncertainty, which lea… …**ity.**

How do we provide users with a coherent story across time scales (seamless information)?



Caron et al. (2015, GRL)

Summary

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

- There is a complex ecosystem of international initiatives relevant to climate predictability and prediction, but very little concerted effort on the required infrastructure.
- Models still have substantial errors that need to be understood and communicated, while forecasts have to deal with a substantial drift.
- There is a strong potential interaction between climate prediction and the attribution of climate events.
- None of this will materialize without appropriate investment in observational networks , infrastructure and reduction of all aspects of model error.